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# Comparative Study of the Viscosity Behavior of Irvingia Gabonensis and Triumfetta Pentandra Polymers

**N. A. Ogolo[1]*, T. Megueptchie[2], M. O. Onyekonwu [1]**

*[1]Institute of Petroleum Studies, University of Port Harcourt, Rivers State, Nigeria*
*[2]Department of Petroleum and Gas Engineering, University of Port Harcourt, Rivers State, Nigeria*
**Corresponding author, Email address: amoniogolo@yahoo.com*

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*amoniogolo@yahoo.com*
*Phone: +234; 8036735160*

**Abstract**

Biopolymers are a class of polymers derived from natural sources such as plants, and two of such biopolymers are extracts from Irvingia gabonensis and Triumfetta pentandra cultivated in West Africa. Viscosity is an important characteristic of polymers which is primarily affected by temperature. In this work, the effect of temperature on the viscosity of the two biopolymers, Irvingia gabonensis and Triumphetta pentandra are investigated for 4, 6 and 8g/l concentrations at temperatures of 15 - 50ºC. The chemical compositions of the polymers were determined using an X-ray Florescence spectrometer and the compositions were compared against each other. Laboratory results show that Triumphetta pentandra is a better polymer than Irvingia gabonensis in terms of viscosity. For all the concentrations considered, a sudden rise in temperature at 30ºC was observed for Triumphetta pentandra which is speculated to be a critical temperature for the polymer. The characterization tests show that Triumphetta pentandra and Irvingia gabonensis contain the same chemical elements but in varying quantities. These variations could be responsible for the highly viscous nature of Triumphetta pentandra over Irvingia gabonensis.

## 1. Introduction

Polymers are important materials with wide applications, ranging from domestic to industrial uses. They are used in various industries which include food, pharmaceutical, construction, ceramic, plastic and the petroleum industry. In the upstream sector of the petroleum industry, polymers are especially required at the tertiary stage of oil recovery when substances other than water and gas are injected into reservoirs to improve sweep efficiency. Presently in the Niger Delta region, oil recovery is still at its secondary recovery stage and preparations are underway to locally source for good enhanced oil recovery (EOR) agents of which polymers are outstanding fluids. Instead of importing EOR agents from abroad into the region, it is of outmost benefit to formulate local EOR agents that will suite the Niger Delta formation and crude types. Hence, locally available materials are studied to determine their suitability as EOR agents for use in future for tertiary oil recovery in the region. This has given rise to conducting research with various locally sourced surfactants, alkaline and polymers.

Polymers are composed of monomers; they can be derived from natural sources such as plants or can be man-made. Naturally derived polymers are called biopolymers while man-made polymers are synthetic polymers. Some biopolymers are edible and at the same time can be used industrially.

Two such biopolymers are extracts obtained from Irvingia gabonensis seeds and Triumfetta pentandra stems, and they are cultivated in West Africa. Irvingia gabonensis is sometimes referred to as bush mango, wild mango, African mango, ogbonno and dika nut, and its light brown mucilage is used locally in preparing nutritious dishes. Triumfetta pentandra is an erect annual plant that grows up to two meters in height with a woody stem and is locally called "kui" in Cameroon. The bark of the stem is a source of a very good polymer that is colorless like water; a mucilage that is edible and medicinal [1]. The polymer is often used for preparing sticky soups and sauces; it is used as food for infants and due to its medicinal and high energy value, it is also used in preparing dishes for nursing mothers. However, information and research studies on this biopolymer are very scanty.

On the other hand, there have been several published literatures on the polymer derived from Irvingia gabonensis. Effects of various conditions on the physiochemical properties of this biopolymer have been investigated [2, 3]. The effect of moisture content on some physical properties of Irvingia gabonensis has been reported [4, 5] and methods of extracting the polymer have been reviewed [6]. Some properties of Irvingia gabonensis have been determined [7] and the effect of microbial fermentation on the polymer has been studied [8]. The nutritious values of Irvingia gabonensis have been discussed [9, 10] and the medicinal values have been studied [11, 12]. There are two classes of Irvingia gabonensis; the sweet and bitter species. Studies on the difference between these two species have been conducted [13]. The effect of storage on the quality of the polymer [14], improvement of its shelf life [15] and modeling of its drying characteristics [16] have been investigated. Studies on the physical, chemical and biochemical properties of Irvingia gabonensis have been reported [17, 18, 19, 20]. All of these show that Irvingia gabonensis polymer has been extensively studied in isolation and there is vast knowledge about its applications, properties, synthesis and nutritional value. But not much is known about it properties in comparison with other biopolymers. This work is however focused on studying the viscosity behavior of polymers derived from Irvingia gabonensis and Triumfetta pentandra within a range of temperatures under different concentrations as well as their compositions.

One important property of polymers that is exploited in various fields of discipline is viscosity. Dynamic viscosity is simply defined as a measure of the internal fluid friction which causes resistance to flow. One major factor that affects viscosity is temperature; generally, the viscosity of a fluid decreases as temperature increases but the extent to which this occurs in polymers varies. In this work, the effect of temperature on the viscosity of Irvingia gabonensis and Triumfetta Pentandra is investigated at different concentrations and the chemical composition of the two biopolymers are determined and compared against each other. It is speculated that the composition of the polymers could have a bearing on the viscosity of the polymers.

## 2. Methodology

### *2.1 Preparation of the polymer extracts*

The Irvingia gabonensis seeds used for this study were grinded into powder and the required masses were weighed and poured into calibrated cylinders. Hot water was poured into the cylinders containing Irvingia gabonensis powders to attain a volume of 1000ml. The mixture was continuously stirred to obtain a homogeneous mixture after which the polymer was allowed to cool down to room temperature. The mixture was then filtered to remove the chaff and the viscosity values of the filtrates at the specified temperatures were determined using an Ostwald U-tube viscometer.

The mature stems of Triumfetta pentandra were obtained and peeled, and the required masses were weighed and dropped in calibrated cylinders. Hot water was poured into the cylinders containing the Triumfetta pentandra until a volume of 1000ml is attained. The hot water helps to extract the mucilage or sap by softening the bark of the plant. The bark of the plant was manually squeezed continuously after which the polymer was allowed to cool down to room temperature. The mixture was then filtered to remove the chaff and the viscosity values of the filtrates at the specified temperatures were also determined using an Ostwald U-tube viscometer.

### *2.2 Experiments*

The different concentrations of Irvingia gabonensis and Triumfetta pentandra used in this study are 4g/l, 6g/l and 8g/l under a temperature range of 15°C to 50°C at 5°C intervals. The Ostwald U-tube viscometer was used to determine the viscosity of the polymers at each concentration and temperature. To characterize the biopolymers, samples of the powder forms of the polymers were used. For Irvingia gabonensis, the same powder used in the experiment were also used for the characterization. For Triumfetta pentandra, the stems of the plant were dried and grinded into powder which was used for the characterization.

### *2.3 Compositional Analysis of the polymers*

Composition of the polymers was determined using an X-ray fluorescence spectrometer. Energy dispersive X-ray fluorescence technology provides one of the simplest, most accurate and economic analytical methods for determining the chemical composition of various materials. In using the spectrometers, all the elements in the sample were excited simultaneously and an energy dispersive detector in combination with a multi-channel analyzer were used simultaneously to collect the fluorescence radiation emitted from the samples. This excitation ejects electrons from the atomic shells of the elements in the sample. When a given atom replaces the ejected electron by taking another electron from an outer atomic shell, x-ray energies are emitted. Each element generates a specific energy level known as characteristic x-rays [21].

## 3. Results and Discussion

### *3.1 Viscosity results with temperature*

The viscosity results of Irvingia gabonensis (IG) and Triumfetta pentandra (TP) are presented in Figures 1 to 5. The viscosity results of the different concentrations of the polymers at 4g/l, 6g/l and 8g/l are presented in Figures 1, 2 and 3 respectively. These three sets of results generally show that the viscosity values of Triumfetta pentandra is far higher than the viscosity of Irvingia gabonensis at all levels of same temperature and concentration. This means that Triumfetta pentandra is a better polymer in terms of viscosity than Irvingia gabonensis. An unusual rise in viscosity can be observed at 30°C for Triumfetta pentandra at all the concentrations considered and the reason for this sudden spike is not clear, constituting an area for further work. Nevertheless, 30°C is speculated to be a critical temperature for the biopolymer.

The collective viscosity results of Irvingia gabonensis and Triumfetta pentandra are presented in Figures 4 and 5 respectively. Figure 4 shows that the viscosity of Irvingia gabonensis at 4g/l and 6g/l are quite close, ranging between 4cp and 10cp while the viscosity results of 8g/l is very wide apart from the results of 6g/l, ranging between 11cp to 16cp for a temperature range of 15 to 50°C. There is no significant observation at any temperature. Figure 5 shows that the viscosity of Triumfetta pentandra at 6g/l and 8g/l are close, ranging between 30cp and 60cp while the viscosity values of 4g/l is far from the results of 6g/l and the values range between 15cp to 32cp for a temperature range of 15 to 50°C. The observed increase at a temperature of 30°C for all the concentrations is glaring; in fact 6g/l and 8g/l concentrations have approximately the same viscosity value of about 58cp at 30°C.

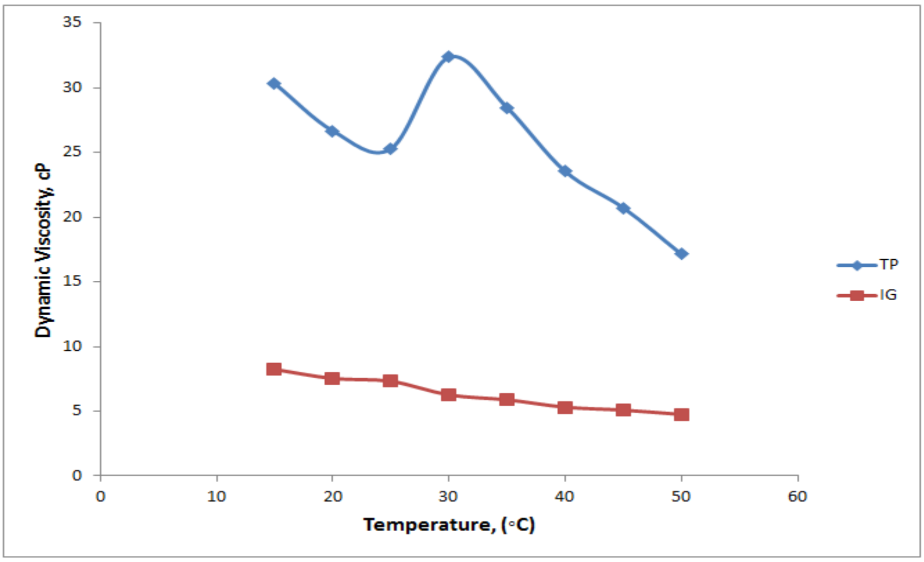



**Figure 1.** Viscosity of TP and IG at varying temperatures for 4g/l

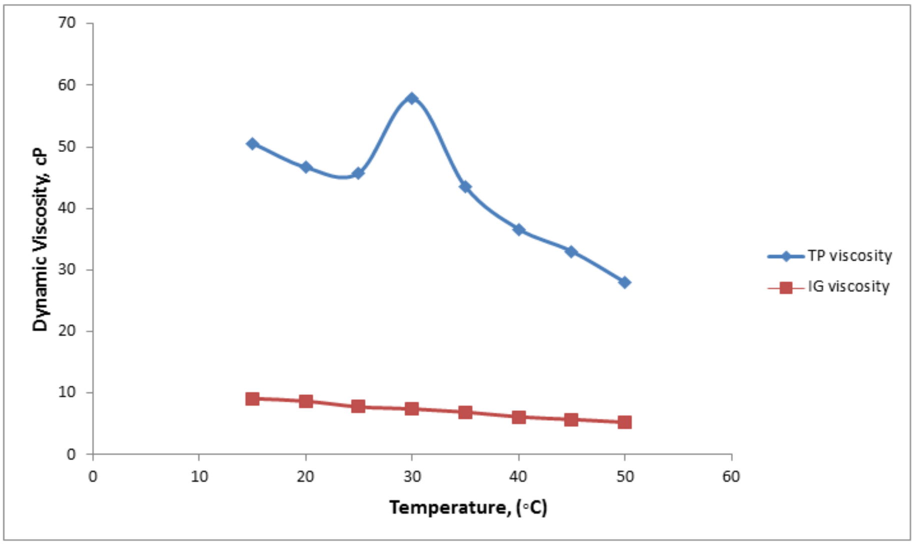



**Figure 2.** Viscosity of TP and IG at varying temperatures for 6g/l

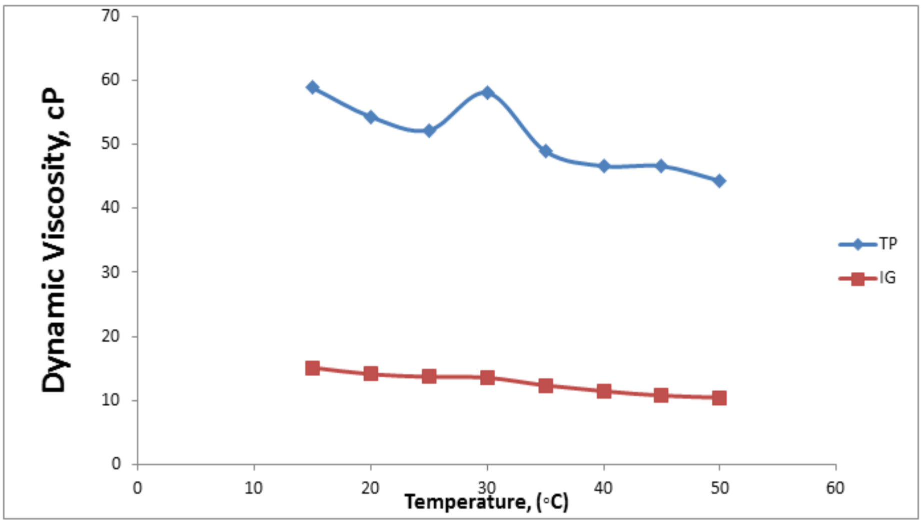



**Figure 3.** Viscosity of TP and IG at varying temperatures for 8g/l

### *3.2 Results of polymer composition*

The results of the compositional analysis of the two biopolymers are presented in Figures 6 to 10. Presented in Figures 6 and 7 are the percentage composition of elements in the polymers while the percentage composition of oxides in the polymers are presented in Figures 8 and 9. The elements and oxides in very minute quantities are presented in Figure 10. It can be observed from the characterization results of the biopolymers that Triumfetta pentandra and Irvingia gabonensis have the same chemical compositions but with variations in percentage content. Probably the variations in the compositional analysis might be responsible for the wide range of viscosity between the two biopolymers. Figures 6 and 7 show that the percentage composition of sulphur, silicon and phosphorus in Irvingia gabonensis is very high compared to the percentage composition in Triumfetta Pentandra. It is uncertain if the low compositions of these elements in Triumfetta pentandra can account for the very high viscosity of this polymer compared to the viscosity of Irvingia gabonensis. Similarly as expected, the percentage compositions of sulphur oxide, silicon oxide and diphosphorus pentoxide are higher in Irvingia gabonensis than in Triumphetta pentandra as observed in Figures 8 and 9.

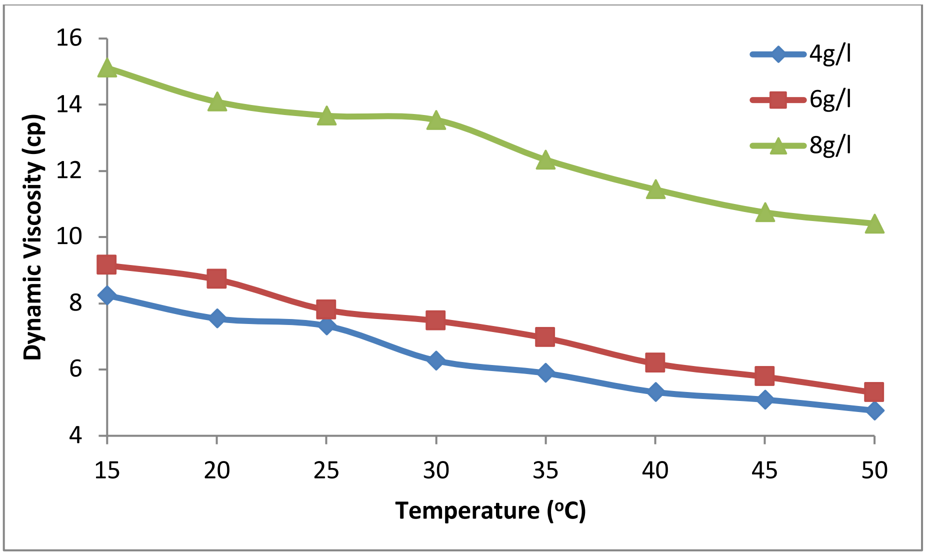



**Figure 4.** Viscosity of Irvingia gabonensis at varying temperatures and concentrations

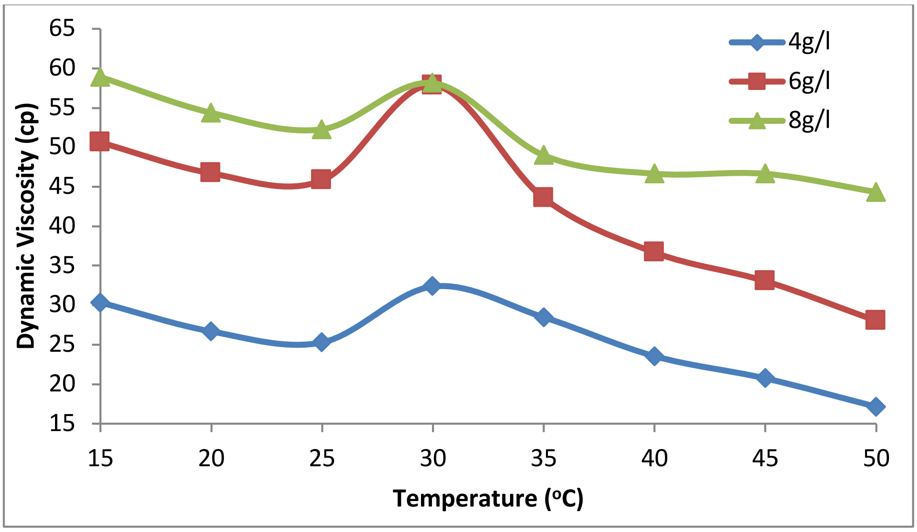



**Figure 5.** Viscosity of Triumfetta pentandra at varying temperatures and concentrations

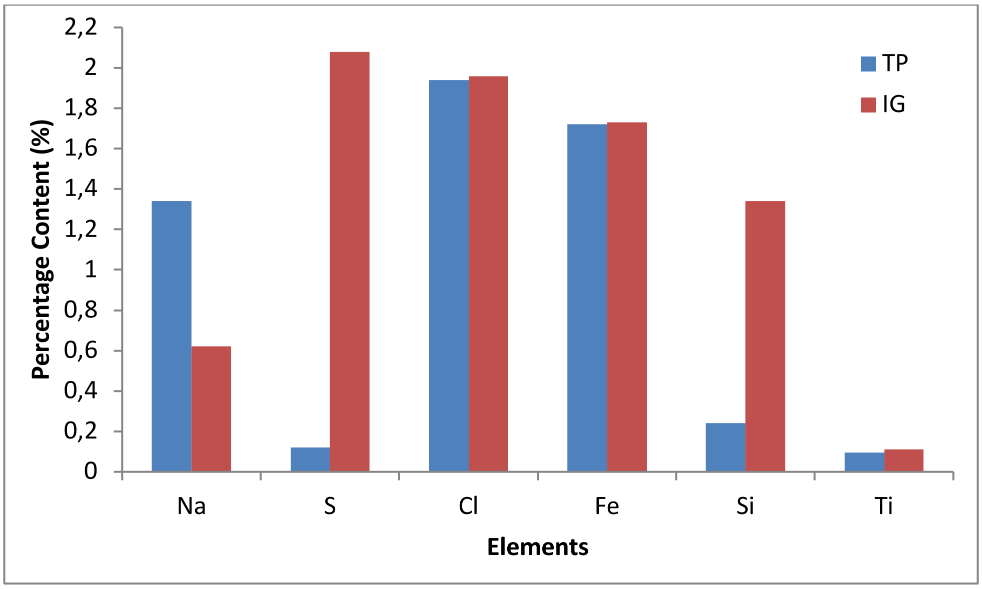
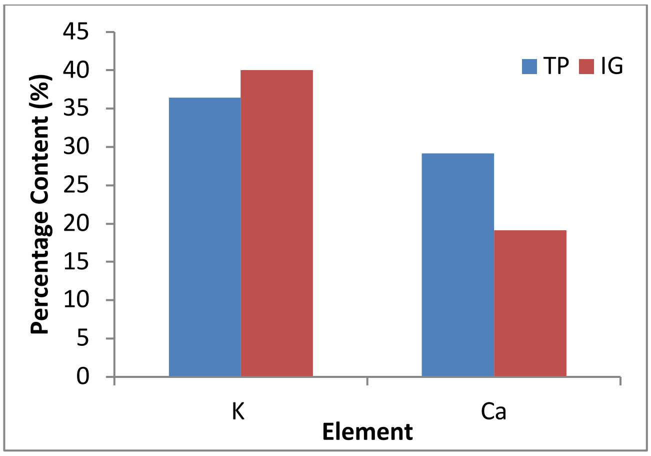



**Figure 6.** Percentage composition of some elements in IG and TP



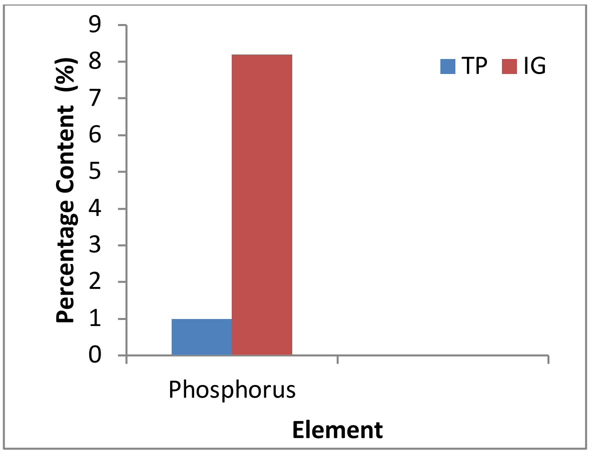




**Figure 7.** Percentage composition of potassium, calcium and phosphorus in IG and TP

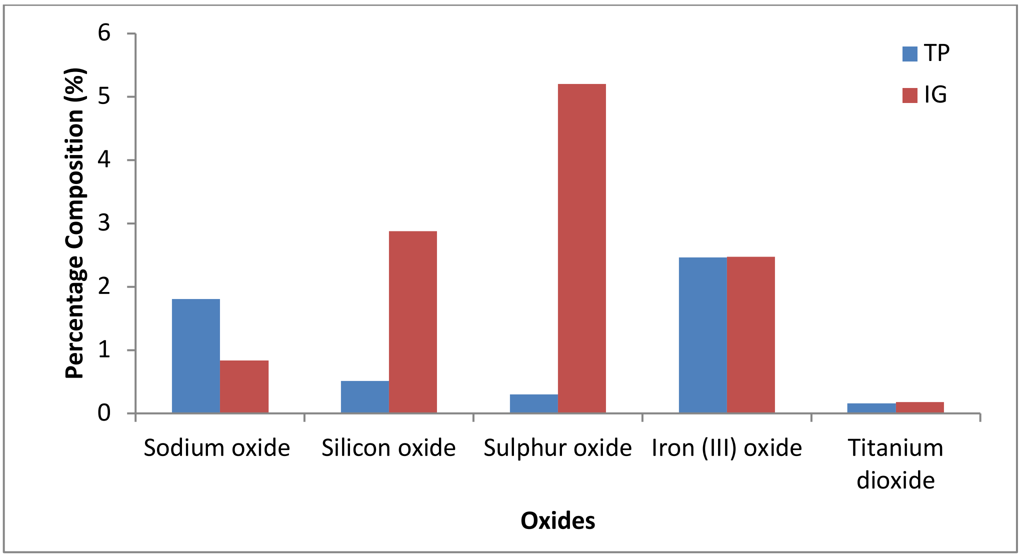



**Figure 8.** Percentage composition of some oxides in IG and TP

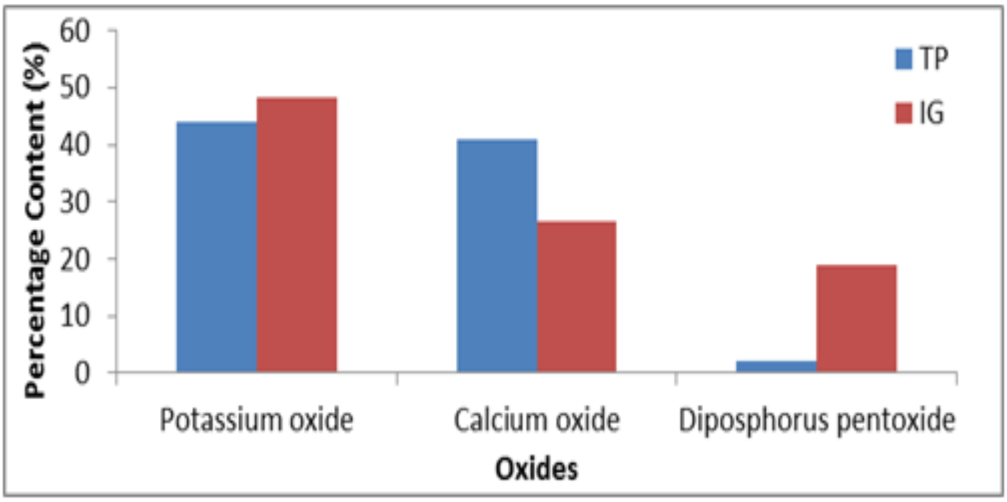



**Figure 9.** Percentage composition of potassium, calcium and diphosphorus oxides in IG and TP

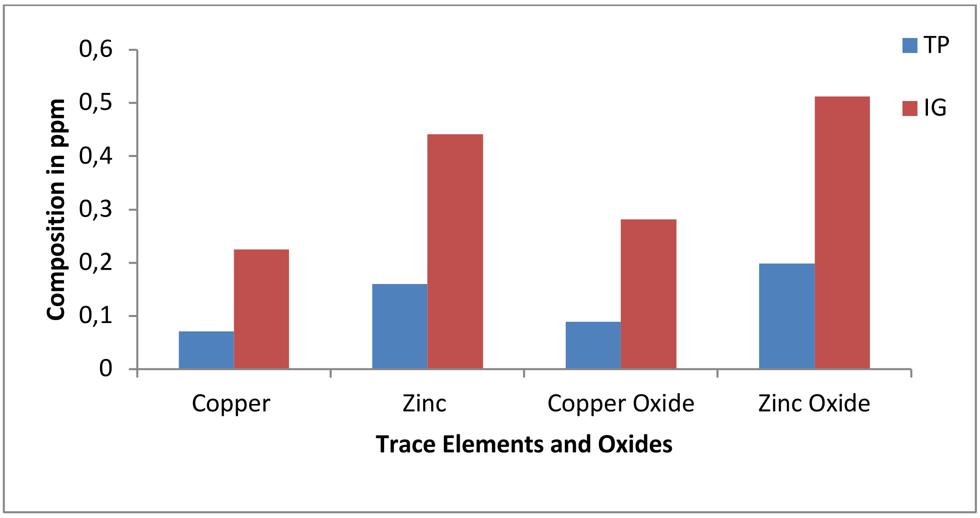



**Figure 10.** Composition of trace elements and oxides in IG and TP

Another observation worthy of note is the high content of sodium, calcium, sodium oxide and calcium oxide in Triumfetta pentandra than in Irvingia gabonensis. It is also not certain if these higher compositions in any way have bearing on the high viscosity of Triumfetta pentandra over the viscosity of Irvingia gabonensis. But it must be pointed out that sodium and calcium are quite close on the periodic table and they are chemical reactive elements while copper and zinc are also close on the periodic table but are transition elements. It should also be noted that the elements and oxides in very minute quantities are more abundant in Irvingia gabonensis than in Triumphetta pentandra as shown in Figure 10.

## Conclusion

Triumfetta pentandra is a better polymer than Irvingia gabonensis in terms of viscosity. There is a sudden significant rise in the viscosity of Triumfetta pentandra at 30°C for all the concentrations considered which is speculated to be a critical temperature for the polymer. For Irvingia Gabonensis, the viscosity values between the concentrations of 4g/l and 6g/l are very close while the viscosity values between 6g/l and 8g/l is very wide. On the contrary for Triumfetta pentandra, the viscosity values between the concentrations of 6g/l and 8g/l are close while the viscosity values between 4g/l and 6g/l is wide. Triumfetta pentandra and Irvingia gabonensis have the same chemical composition but with variations in the percentage content. It is speculated that these variations might be responsible for the very high viscosity of Triumphetta pentandra over the viscosity of Irvingia gabonensis at all the temperatures and concentrations considered.

**Recommendation :** Triumphetta pentandra is a better biopolymer than Irvingia gabonensis in term of viscosity at same concentrations and temperatures.

**Disclosure statement:** *Conflict of Interest:* The authors declare that there are no conflicts of interest. *Compliance with Ethical Standards:* This article does not contain any studies involving human or animal subjects.

## References


[1] K. J. Dzotam, K. F. Touani and V. Kuete, "Antibacterial Activities of the Methanol Extract of Canarium Schweinfurthii and Four other Cameroonian Dietary Plan against Multi-drug Resistant Gram-negative Bacteria" *Saudi Journal of Biological Sciences,* 23 (2016) 565 – 570.

[2] E. D. I. Mustapha and A. A.Taleat, "Physiochemical Properties and Fatty Acid Composition of Dika Nut (Irvingia Gabonensis) Seed Oil" *Research Journal of Chemical Sciences,* 4:(12) (2014) 70 – 74.

[3] O. O. Ekpe, S. A. Bassey, A. L. Udefa and N. M. Essien, "Physiochemical Properties and Fatty Acid Profile of Irvingia Gabonensis (Kuwing) Seed Oil" *International Journal of Food Science and Nutrition*, 3:(4) (2018) 153 – 156.

[4] I. A. Iyilade, A. K. Arewu, N. A. Aviara and S. K. Oyeniyi, "Effect of Moisture Content on the Physical Properties of Bush Mango (Irvingia Gabonensis) Nut" *AgricEngInt: CIGR Journal* Open Access, 20:(4) (2018) 221 – 226.

[5] O. O. Awolu and B. A. Oluwafemi, "Effect of Moisture Content on the Mechanical Properties of Dike (Irvingia Gabonensis) Fruit and Nut" *British Journal of Applied Science and Technology, Science Domain International*, 3(4) (2013) 1569 – 1577.

[6] I. J. Ogaji, A. Nan and S. W. Hong, "A Novel Extraction Method and Some Physicochemical Properties of Extractives of Irvingia Gabonensis Seeds" *Journal of Young Pharmacists: JYP, Elsevier, J Young Pharm.,* 4(2) (2012) 66 – 72.

[7] B. A. Orhevba, P. A. Idah, S. E. Adebayo and C. C. Nwankwo, "Determination of Some Engineering Properties of Dika Nut (Irvingia gabonensis) at Two Moisture Content Levels as Relevant to its Processing" *International Journal of Engineering Research and Application (IJERA),* 3(2) (2013) 182 – 188.

[8] F. O. Ekundayo, O. A. Oladipupo and E. A. Ekundayo, "Studies on the Effects of Microbial Fermentation on Bush Mango (Irvingia Gabonensis) Seed Cotyledon" *African Journal of Microbiology, Academic Journals,* 7:(34) (2013) 4363 – 4367.

[9] O. P. Bamidele, O. S. Ojedokun and B. M. Fasogbon, "Physico-chemical Properties of Instant Ogbono (Irvingia gabonensis) Mix Powder" *Food Science and Nutrition,* 3:(4) (2015) 313 – 318.

[10] L. Meteus-Reguengo, L. Barbosa-Pereira, W. Rembangouet, M. Bertolino, M. Giodano, O. Rojo-Poveda and G. Zeppa, "Food Application of Irvingia Gabonensis (Aubry-Lecomte ex. O'Rorke) Baill; the Bush Mango: A Review" *Critical Reviews in Food Science and Nutrition,* 60:(14) (2020) 2446 - 2459.

[11] E. G. Anaduaka, “Biochemical Changes associated with the Administration of Aqueous Pulp Extract of Irvingia Gabonensis Fruit on Adult Wister Rats” *Clinical Nutrition,* Open Science, ScienceDirect, 42 (2022)6 – 13.
[12] O. O. Dosumu, O. O. Oluwaniyi, G. V. Awolola and O. O. Oyedeji, “Nutritional Composition and Antibacterial Properties of three Nigerian Condiments” *Nigerian Food Journal, NIFOJ,* 30 No. 1 (2012) 43 – 52.
[13] R. Vihotogbe, N. Raes, R. G. Van den Berg, B. Sinsin and M. S. M. Sosef, “Ecological Niche Information Supports Taxanomic Delimitation of Irvingia gabonensis and I. Wombolu (Irvingiaceae)” Elsevier ScienceDirect, *South African Journal of Botany,* 127 (2019) 35 – 42.
[14] T. Adedeji, “Effect of Storage Period on the Quality Characteristics of Two Varieties of African Mango Seed Flour at Ambient Temperature” *Heighten Science Publications,* Open Access, (2017).
[15] C. J. Adeseko and O. T. Lawal, “Purification and Biochemical Characterization of Polyphenol Oxidase of African Bush Mango (Irvingia gabonensis) Fruit Peel” *Biocatalysis and Agricultural Biotechnology,* 36 102119, (2021).
[16] O. A. Aregbesola, B. S. Ogunsina, A. E. Sofolahn and N. N. Chime, “Mathematical Modeling of thin Layer Drying Characteristics of Dika (Irvingia Gabonensis) Nuts and Kanels” *Nigerian Food Journal,* 33 (2015) 83 – 89.
[17] B. A. Ogunsina, A. S. Bhatnagar, T. N. Indira and C. Radha, “The Proximate Composition of African Bush Mango Kernels (Irvingia Gabonensis) and Characteristics of its Oil” *Ife Journal of Science,* 14:(1) (2012) 177 – 183.
[18] F. U. Asoiro, S. L. Ezeoha, C. N. Anyanwu and N. N. Aneke, “Physical Properties of Irvingia Gabonensis, Deuterium Microcapum, Mucuna Pruriens and Brachystegia Eurycoma Seeds” *Heliyon* 6 (2020) e04885.
[19] M. L. Nwokocha and E. K. Nwokocha, “Chemical Composition and Rheological Properties of Detarium Microcarpum and Irvingia Gabonensis Seed Flour” *Scientific African,* 10 (2020) e005291.
[20] C. J. Adeseko, D. M. Sanni and O. Lawal, “Biochemical Studies of Enzyme-induced Browning of African Bush Mango (Irvingia Gabonensis Fruit Pulp” *Preparative Biochemistry and Biotechnology,* (2021) 1 – 12.
[21] R. S. Clapera, “Energy Dispersive X-Ray Fluorescence: Measuring Elements in Solid and Liquid Matrices” *Karel de Grote-Hogeschool Antwerpen Industriële Wetenschappen en Technologie,* 1(10256/7563) (2006) 35-66.

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